Controlling Conducted and Radiated EMI issues in Power Electronics Designs

Dr. Supratim Basu and Prof. Tore Undeland

Seminar Presentation Abstract:

While management of EMI in Power Electronics design has always not been very straightforward, today's demand for power converters having higher power densities and efficiencies makes EMI management even more challenging. While higher power densities make the converter's EMI filter very susceptible to internal fields, demands for fast switching speeds of switching devices to minimize switching losses and improve efficiency, also increases EMI significantly. Thus as higher power densities and efficiencies driving today's designs conflict with the general rules of EMI management, the general design approach of using the best highest inductance filter after completing design often usually never works, resulting in significant project delays. Therefore understanding the generation of EMI and its reduction at source during design, is the key to controlling EMI.

This intermediate to advanced level course will begin with a refresh on EMI basics followed by an in-depth treatment of various topics like heat-sink grounding, transformer screens, using ferrite beads, filter design, PCB layout, Mosfet switching speed, etc. Lastly the focus of this presentation is to present everything with as many practical engineering examples as possible and thus have a mix of both practice and theoretical explanations and not focus only on field/wave theory or physics.

Presenting Speakers and Affiliations:

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Tutorial-*Part 1*

Introduction and Overview

Overview of EMI

Understanding EMI /EMC ● Conducted (CE) & Radiated Emission (RE) and its generation.

EMI Basics

Electrostatic & Magnetic coupling ● Generation of Noise current and return paths ● Common & Differential Mode Noise ● Harmonic components of noise ● Ground plane, grounding and high frequency current paths ● Electric & Magnetic Field Noise Emissions, Near & Far Fields ● Conductors become Antennas and it can both radiate and receive ● Understanding EMI energy transformation between CE to RE at 30 MHz ● Shields and Influence of Apertures.

Measuring EMI

Challenges in EMI measurement ● Transducers for measuring CE and RE ● Causes of measurement uncertainties in CE and RE.

Conclusion, Summary, Questions from Audience and discussions.

Break

Tutorial-*Part 2*

Understanding EMI in Power Electronics

EMI from Power Electronic Circuits and strategies for controlling it at source.

Topology selection...hard switched versus resonant converters. ● Emissions from high dV/dt surfaces and remedies ● Heat-sinks and common mode currents ● Heat-sink to device capacitance, Heat-sink shields, Topology selection. ● Common Mode currents through transformer inter-winding capacitances ● Transformer Shields and Flux Straps ● dI/dt Current loops and Radiated Magnetic ● Field Coupling ● Radiated Magnetic Fields from Magnetic Circuits ● Cross Talk/Near Field Interference ● Circuit parasitic elements and switching speed of Mosfets, IGBTs ● Diode reverse recovery characteristics ● Circuit parasitic elements, ringing and damping ● Passive and regenerative snubber Circuits ● Ferrite Beads ● Common mode and Differential mode radiated emissions.

Conclusion, Summary, Questions from Audience and discussions.

Break

Tutorial-*Part 3*

Designing For EMC

PCB Layout issues.

● Understanding generation of fields from PCB ● Identifying tracks with high dV/dt and high dI/dt. ● E field and B field coupling ● Minimizing HF current paths and allowing dc bus dominance ● Shortest track length and balancing switching currents considerations ● Understanding how significant resistance, inductance, mutual capacitive coupling and mutual inductance with other PCB traces exist as PCB traces are not perfect equipotential conductors ● Influence of PCB trace inductance on ringing, voltage spikes, switching loss and associated EMI. ● Good converter design always has low high frequency ringing emissions without the need for a slow switching speed or significant snubber dissipation ●Internal circuit ground node is never at zero potential causing circulating ground loop currents that cause EMI. Limiting ground loop currents in the PCB is often the key ● Minimizing coupling of signals and fields by proper component placement ● Clock signals are notorious. Keeping them shortest in length is the best ● Multi layer PCBs.

Conclusion, Summary, Questions from Audience and discussions.

Filtering EMI

Principles of filtering CE and RE. Design of Practical Filters.

● Noise Coupling Modes and paths ● How noise current flow can contributes to both CE and RE. ● Conductors act as Antennas as they carry noise current ● Improper earthing or high earth resistance significantly increases EMI ● How filters limit both CE and RE ● Safety Capacitors and Leakage currents ● A typical EMI filter and how it works ● Influence of Leakage currents on filter attenuation ● Understanding EMI Filters, attenuation and insertion loss ● Common Mode Filters, Differential Mode Filters and Earth Line Chokes ● Parasitics and frequency response of filters ● EE cores versus Torroidal cores ● Understanding winding capacitance & influence of overlapping of windings ● Multistage filters and total attenuation ● Differential mode filter design ● Common mode filter design. ● Filter damping and interface issues ● Mitigating Radiation coupling to filters ● Shielding EMI filters and their importance ● Placement of EMI filters and influence on Board Layout ● How placement of EMI filters significantly influences Radiated Emission.

Conclusion, Summary Questions from Audience and discussions.

End of Seminar Presentation

Biography of Presenting Speakers and Authors:

Supratim Basu received the B.E. degree in electrical and electronics engineering from Birla Institute of Technology, Mesra, India, in 1988 and the M.Tech. degree from Indian Institute of Science, Bangalore, India, in 1992. He received the Ph.D. degree from Chalmers University of Technology, Göteborg, Sweden in 2006.

He has published many technical papers in the area of power electronics. His current research interests are power electronics applications to Renewable Energy and EMI/EMC. He is also associated with Aalborg University, Denmark, Helsinki University of Technology, Finland and NTNU, Norway for lecturing in EMI/EMC and Mosfet drive circuits. He has also presented many lectures on Power Electronics design for many industries in Europe and is also actively involved in developing lectures for large corporations for their internal training programs and training seminars. He chaired a Workshop and Panel discussion on EMI at the European Conference on Power Electronics and Applications, EPE 2007, Aalborg, Denmark and presented many Tutorials at IEEE-PESC 2008, Rhodes, Greece; EPE-2009, Barcelona, Spain; IEEE-IECON 2009,Porto, Portugal, IEEE-APEC 2010,Palm Springs, USA.

He has been associated with power electronics R&D since 1992 and has independently developed many converters and inverters. Presently he is managing director at Bose Research Pvt. Ltd, Bangalore, India and heads a research and development team of ten power electronics engineers. He also works as an independent power electronics consultant for many companies around the world.

Tore M. Undeland (M'86, SM'92, F'00) is Professor of power electronics at the Norwegian University of Science and Technology, Trondheim, Norway and Chalmers University of Technology, Göteborg, Sweden. He has been teaching since 1972 and as a Professor since 1984. He has authored many publications in the field of power converters, snubbers, and control in power electronics. He is a coauthor of the book *Power Electronics: Converters, Applications, and Design* (New York: Wiley, 2003).

Dr. Undeland was the chairman of the European Power Electronics and Drives Association (EPE) 1997 Conference, Trondheim, and is presently member of EPE. He is a Fellow of IEEE. For six years he is a member of the AdCom, IEEE Power Electronics Society.